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# Effects of Photoperiod Manipulation on Reproductive Condition of the Northern Bay Scallop, *Argopecten irradians irradians* (Lamarck, 1819)

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*Abstract.* Recent studies suggest that photoperiod may play an important role in reproductive development of certain scallop species, but similar investigations have not been done previously for the bay scallop. In this study, we exposed bay scallops, *Argopecten irradians irradians* (Lamarck, 1819), during late reproductive development but prior to spawning, to three different light regimens (24 hr light, 24 hr dark, and ambient light) in the laboratory. Scallops from all treatments showed increases in reproductive condition over a 4-week period, but those held under continuous light showed a statistically greater increase in reproductive condition as early as 6 days after the start of the experiment. Our data suggest that photoperiod may play a significant role in affecting the reproductive condition of bay scallops.

## INTRODUCTION

Changes in water temperature and food availability are generally regarded to be the major exogenous factors that cue the process of reproductive development in temperate bivalve mollusks (Sastry, 1963, 1966, 1968; Sastry & Blake, 1971; Bayne, 1976; Newell et al., 1982; MacDonald & Thompson, 1985). Photoperiod has usually been viewed as playing a minor role, or no role whatsoever, in gametogenesis of bivalves, but given the well-developed nature of the pectinid eye, it is probable that light plays an important role in scallop reproduction (Devauchelle & Mingant, 1991). Evidence is mounting that photoperiod may be important in the reproductive development of such pectinid species as *Pecten maximus* (Paulet & Boucher, 1991; Devauchelle & Mingant, 1991; Saout et al., 1999), *Placopecten magellanicus* (Couturier & Aiken, 1989), and *Argopecten circularis* (Villalejo-Fuerte & Ochoa-Baez, 1993). While reproduction has been extensively studied in the bay scallop, *Argopecten irradians* (see review by Barber & Blake, 1991); effects of photoperiod on gonadal maturation have not been investigated. The purpose of this study was to examine how manipulation of photoperiod affected gonad weight and reproductive (gonadal) index during the late stages of reproductive development, prior to spawning, of the northern bay scallop, *Argopecten irradians irradians.*

## MATERIALS AND METHODS

Effects of photoperiod manipulation on bay scallop reproductive development were monitored over a 4-week period, from mid-May to mid-June 2003, by exposing 0+ yr hatchery-reared scallops which had been overwintered in Goose Creek, Southold, New York, USA to three different light regimens: (1) ambient light (diurnal sunlight approaching maximum day-length in late June), (2) continuous darkness (effected with light impermeable fiberglass tanks and covers), and (3) continuous light (provided by an overhead bank of four 1.23 m long, 40- watt Cool White® fluorescent light tubes). Each of the three groups of scallops (n = 95) was held in separate opaque, fiberglass raceway tanks (0.9 m wide × 2.5 m long × 0.6 m deep) supplied with unfiltered, ambient flowing seawater from Cedar Creek at the Southold Marine Environmental Learning Center in Southold, New York. Flow rate was 113.61 (=30 gal)/min; temperature ranged from 14.4–18.9°C, while salinity remained at ~28 ppt during the study period. All tanks were cleaned on a weekly basis, following removal of scallops, with a strong stream of water. At the time of initial collection on 14 May 2003, shell heights of 15 scallops were measured to the nearest mm ($\bar{x}$ = 48 mm; SD = 3.3 mm) and a baseline of reproductive condition of these animals was determined via measurement of gonad dry weight (GDW) and gonadal index (GI = (gonad dry weight) / (total tissue dry weight) × 100) (Barber & Blake, 1991). Shell heights, GDW, and GI of 15 bay scallops sacrificed from each of the three photoperiod treatments (ambient, dark, light) were similarly measured at approximately weekly intervals during the ensuing 4-week period.

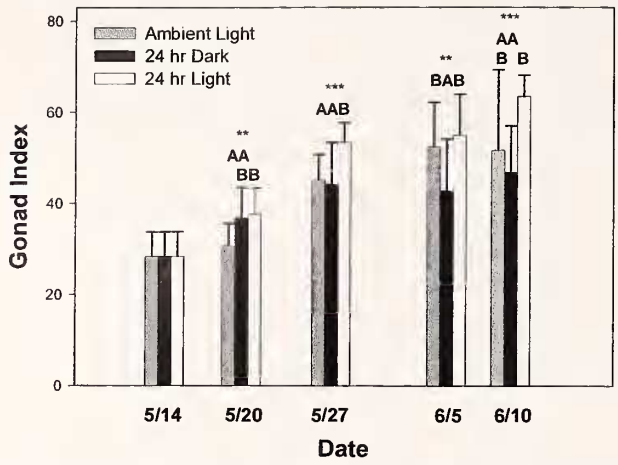


Figure 1. Temporal changes in gonad index (GI) of hatchery-reared 0+ yr bay scallops, *Argopecten irradians irradians*, exposed to three different light regimens (ambient light, 24 hr dark, 24 hr light) in the laboratory from 14 May–10 June 2003. Bars represent mean values + 1 SD; n = 15 individuals per group, per sample date. Statistical differences between means for a given date, as determined via Kruskal-Wallis non-parametric ANOVA, are shown above the bars; ** = $P < 0.01$; *** = $P < 0.001$. Letters shown above the bars signify results of Tukey-type non-parametric multiple comparisons; dates having the same letter are not statistically different at $P < 0.05$.

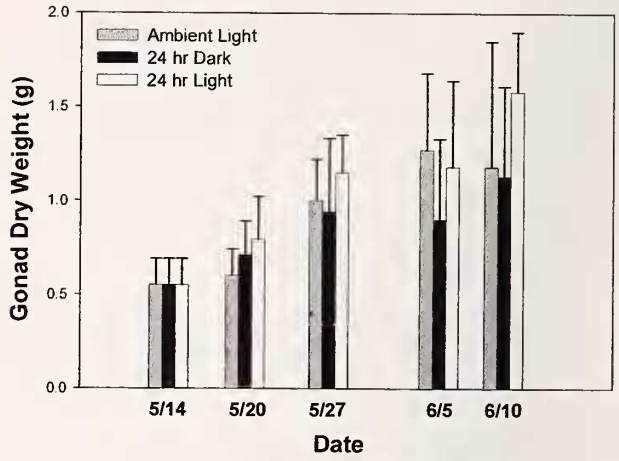


Figure 2. Temporal changes in gonad dry weight (GDW) of hatchery-reared 0+ yr bay scallops, *Argopecten irradians irradians*, exposed to three different light regimens (ambient light, 24 hr dark, 24 hr light) in the laboratory from 14 May–10 June 2003. Bars represent mean values + 1 SD; n = 15 individuals per group, per sample date. While there were statistical differences (at $P < 0.04$) between means on 5/20, 6/5, and 6/10, as determined via Kruskal-Wallis non-parametric ANOVA's, there were no statistical differences (at $P < 0.05$) shown in any of the Tukey-type non-parametric multiple comparisons.

## RESULTS

Bay scallops held under each of the three different photoperiod treatments (ambient, 24 hr dark, 24 hr light) showed progressive increases in reproductive condition, as evidenced by increases in mean GI and mean GDW by the end of the 4-week study period (Figures 1, 2). Scallops held under the 24-hr light regimen showed a consistent increase in both GI and GDW at each of the four sampling periods, while scallops held under ambient photoperiod or continuous darkness showed an increase in GI and GDW for the first 2 weeks, but some fluctuation thereafter. There was no evidence that extensive spawning occurred in any of the scallop groups, as would have been evidenced by a sharp decline in GI and GDW following a steady increase (Barber & Blake, 1991).

Significant differences in reproductive condition of scallops from the three groups were apparent as early as 6 days after exposing scallops to the different photoperiods (Figures 1, 2). Raw and transformed GI and GDW values were non-normal, so parametric analyses were precluded, but Kruskal-Wallis non-parametric ANOVA's (Zar, 1984) of GI versus photoperiod treatment, at each of the four sampling dates, were each statistically significant at $P < 0.01$ (Figure 1). Following these analyses, Tukey-type non-parametric multiple comparisons (Zar, 1984) showed that GI of scallops held under 24-hr light was significantly higher, at $P < 0.01$, than GI of ambient scallops on 20 May, significantly higher than GI of both ambient and 'dark' scallops on 27 May, and significantly higher than those of 'dark' scallops on both 5 June and 10 June. Comparable Kruskal-Wallis ANOVA's of GDW versus photoperiod treatment were significantly different, at $P < 0.04$, for the 20 May, 5 June, and 10 June sample dates, but were not different on 27 May ($P = .0651$). Tukey-type multiple comparisons, however, did not reveal significant differences, at $P < 0.05$, between GDW of scallops from the three treatment groups on any of the four sampling dates. No differences in shell heights of scallops were apparent during the course of the study, as revealed by a 2-way parametric ANOVA of shell height versus photoperiod treatment ($P = 0.0911$), sample date ($P = 0.1267$), and treatment × date interaction ($P = 0.234$). No scallop mortality was recorded during the study.

## DISCUSSION

Our data suggest that photoperiod may play a significant role in affecting the reproductive condition of bay scallops, *Argopecten irradians irradians*. Effects of photoperiod manipulation were also manifested rapidly, as early as 6 days after deployment of scallops under the three different photoperiod regimens. Bay scallops exposed to the different photoperiods all showed

increases in reproductive condition (both GI and GDW) over the course of the 4-week study, but, relative to initial values, scallops exposed to 24-hr light had significantly higher GI levels than those of scallops exposed to ambient light or 24 hr dark conditions. The lack of clear statistical differences amongst GDW of scallops in the three photoperiod treatment groups was likely due to variability of gonad weights of scallops used in the experiment.

Photoperiod was the only variable manipulated in our experiments, and thus we conclude that the manipulation of photoperiod was directly responsible for the observed differences in scallop reproductive development. A potential indirect effect of light manipulation might have been an elevated level of algal growth, and hence food, in experimental tanks exposed to longer photoperiods. Walls of the 24 hr-light tanks qualitatively appeared to have a heavier biofilm layer than those of the other tanks at the time of the weekly cleanings. Given the flow rate in the tanks (113.61(=30 gal)/min), however, it is unlikely this could have affected seston levels in the tanks. While benthic microalgae may be potentially important to the diet of bay scallops (Davis & Marshall, 1963), it does not seem likely that this nutritional source would have been significantly different in the three tanks due to the frequency with which tanks were cleaned. Thompson et al. (1994) showed that larvae of *Patinopecten yessoensis* (= *P. caurinus yessoensis*) grew faster and were larger after 18 d when fed phytoplankton (*Pavlova lutheri* or *Chaetoceros simplex*) grown under high vs. low light levels; they concluded that this difference was due to the higher levels of short-chain saturated fatty acids in the algae grown under high light conditions. Again, given the high flow rate and very brief residence time of phytoplankton in our tanks, it is unlikely that the different light regimens affected the biochemical composition of the ambient phytoplankton species while in the tanks.

Our conclusions about the effects of photoperiod on reproductive development in *Argopecten irradians irradians* appear to corroborate the conclusions of Devauchelle & Mingant (1991). These authors demonstrated that *Pecten maximus* showed accelerated gametogenesis when exposed to increased photoperiod length (15 hrs light increased to 15.15 or 18.3 hrs light), compared to scallops held under short and constant light (8 hr) or when photoperiod length was reduced (from 14 or 15 hrs light to 8.3 hrs). Furthermore, they found that decreasing photoperiod reduced gametogenic activity and numbers of eggs spawned by mature *Pecten maximus*.

The effects of photoperiod manipulation may be of value to scallop aquaculture. Exposure of scallops to longer photoperiods might potentially result in faster, or in higher levels of, egg production, as determined by Devauchelle & Mingant (1991). In our study, the mean GI values for scallops exposed to continuous light for between 2–4 weeks (53.3–63.4) were considerably higher than maximum mean GI values reported for 0+ yr scallops from natural populations (Epp et al., 1988: 29.2–32.0; Tettelbach et al., 1999: 33.1–38.0; Tettelbach et al., 2002: 37.0–44.5) and hatchery stocks (Davidson, 2000: 30.1–34.1; Tettelbach et al., 2002: 35.2–35.8) sampled from the field in eastern Long Island, New York at comparable times in the reproductive cycle, mid-May to mid-June. While the high GI levels that we observed may be reflective of differences in relative reproductive investment of scallops from different source populations (Parsons et al., 1992), they also appear to reflect the positive effects of exposure to longer photoperiod. Further investigation of the effects of light on the reproductive development of bay scallops should provide further scientific insight as well as potentially useful applications to aquaculture.

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